which commence as far back as the end of the fifteenth century, the various expeditions sent out by private enterprise, those despatched for military, naval, or diplomatic purposes, or, finally, the various hydrographic or geodetic surveys undertaken by the French authorities in Cochin China.

THE teachers at the school for the sons of Japanese nobles in Tokio appear to have hit upon a notable method of teaching physical geography. In the court behind the school building is a physical map of the country, between three and four hundred feet long. It is made of turf and rock, and is bordered with pebbles, which look at a little distance much like water. Every inlet, river, and mountain is reproduced in this model with a fidelity to detail which is wonderful. Latitude and longitude are indicated by telegraph wires, and tablets show the position of the cities. Ingenious devices are employed in illustrating botanical studies also. For example, the pine is illustrated by a picture showing the cone, leaf, and dissected flower, set in a frame which shows the bark and longitudinal and transverse sections of the wood.

IN No. 103 of the *Zeitschaft* of the Berlin Geographical Society will be found a fine series of new large scale maps by H. Kiepert on the region containing the ruins of Babylon, embodying the results of new surveys and explorations. In the same number Herr Karl Schneider has a long paper on the valley formations of the Eifel.

PROF. FRIES has written an interesting paper proposing that part of Greenland should be colonised by Lapps. He maintains that the country would be a paradise to the mountain Lapps, that it is no more inhospitable than their own country, that there would be no restrictions to their wanderings, and that in the interior in summer and on the coast in winter they would find abundant forage for their herds. Prof. Fries is of Nordenskjöld's opinion, that in the interior abundant reindeer pasture will be found. Moreover, as a Lapp can always follow where a reindeer leads, this would be an excellent plan of discovering the true nature of the interior; it seems certainly worth trying.

Two gentlemen from Münster (Westphalia)—Dr. Bachmann and Dr. Friedrich Wilms—are about to start on a scientific tour to Southern Africa, the Transvaal to begin with, in order to make zoological and botanical researches. Their journey will extend over several years, and the travellers will endeavour to establish direct commercial relations between the South African colonies and Germany.

ELECTRICAL UNITS OF MEASUREMENT[1]

THE lecturer began by observing that no real advance could be made in any branch of physical science until practical methods for a numerical reckoning of phenomena were established. The "scale of hardness" for stones and metals used by mineralogists and engineers was alluded to as a mere test in order of merit in respect to a little understood quality, regarding which no scientific principle constituting a foundation for definite measurement had been discovered. Indeed it must be confessed that the science of strength of materials, so all important in engineering, is but little advanced, and the part of it relating to the quality known as hardness least of all.

In the last century Cavendish and Coulomb made the first advances towards a system of measurement in electrical science, and rapid progress towards a complete foundation of the system was effected by Ampère, Poisson, Green, Gauss, and others. As late as ten years ago, however, regular and systematic measurement in electrical science was almost unknown in the chief physical laboratories of the world; although as early as 1858 a practical beginning of systematic electric measurement had been introduced in the testing of submarine telegraph cables.

A few years have sufficed to change all this, and at this time electric measurements are of daily occurrence, not in our scientific laboratories only, but also in our workshops and factories where is carried on the manufacture of electric and telegraphic apparatus. Thus ohms, volts, amperes, coulombs, and microfarads are now common terms, and measurements in these units are commonly practised to within one per cent. of accuracy. It seems, indeed, as if the commercial requirements of the application of electricity to lighting and other uses of everyday life were destined to influence the higher region of scientific investigation with a second impulse, not less important than that given thirty years ago by the requirements of submarine telegraphy.

A first step toward the numerical reckoning of properties of matter is the discovery of a continuously varying action of some kind, and the means of observing and measuring it in terms of some arbitrary unit or scale division; while the second step is necessarily that of fixing on something absolutely definite as the unit of reckoning.

A short historical sketch was given of the development of scientific measurement, as applied to electricity and magnetism, from its beginning with Cavendish about 100 years ago, to the adoption of the absolute system of measurement by this country in 1869, at the instance of the British Association Committee on Electric Standards. The importance in this development of the originating works of Gauss and Weber was pointed out, as also of the eight years' labours of the British Association Committee. This Committee not only fairly launched the absolute system for general use, but also effected arrangements for the supply of standards for resistance coils, in terms of a unit, to be as nearly as possible 10^9 centimetres per second. This unit afterwards received the name of the ohm, which was adopted from a highly suggestive paper which had been communicated to the British Association in 1861 by Mr. Latimer Clark and Sir Charles Bright, in which some very valuable scientific methods and principles of electric measurement were given, and a system of nomenclature—ohmas, kilohmas, farads, kilofarads, volts, and kilovolts—now universally adopted with only unessential modification, was proposed for a complete system of interdependent electric units of measurement. At the International Conference for the Determination of Electrical Units held at Paris in 1882, the absolute system was accepted by France, Germany, and the other European countries; and Clark and Bright's nomenclature was adopted in principle and extended.

Gauss's principle of absolute measurement for magnetism and electricity is merely an extension of the astronomer's method of reckoning mass in terms of what may be called the universal gravitation unit of matter, and the reckoning of force, according to which the unit of force is that force which, acting on unit of mass for unit of time, generates a velocity equal to the unit of velocity. The universal-gravitation unit of mass is such a quantity of matter, that if two quantities, each equal to it, be placed at unit distance apart, the force between them is unity.

Here mass is defined in terms of force and space, and in the preceding definition force was defined in terms of mass, space, and time. Eliminating mass between the two, it will be found that any given force is numerically equal to the fourth power of the velocity with which any mass whatever must revolve round an equal mass, fixed at such a distance from it as to attract it with a force equal to the given force. And, eliminating force between the two primitive definitions of the universal-gravitation system, it will be found that any given mass is numerically equal to the square of the velocity with which a free particle must move to revolve round it in a circle of any radius, multiplied by this radius. Thus, take a centimetre as the unit of length, and a mean solar second as the unit of time, and adopt 5·67 grammes per cubic centimetre as the mean density of the earth from Baily's repetition of Cavendish's experiment, and suppose the length of the seconds' pendulum to be 100 centimetres, and neglect the oblateness of the earth and the centrifugal force of its rotation (being at the equator only 1/289 of gravity), the result for the universal gravitation units of mass and force is respectively 15·36 French tons, and 15·36 megadynes, or 15·07 times the terrestrial surface-weight of a kilogram.

The ultimate principles of scientific measurement were illustrated by the ideal case of a traveller through the universe who has brought with him on his tour no weights, no measures, no watch or chronometer, nor any standard vibrator or spring balance, but merely Everett's units and constants, and a complete memory and understanding of its contents, and who desires to make for himself a metrical system agreeing with that which he left behind him on the earth. To recover his centimetre the readiest and most accurate way is to find how many wavelengths of sodium light there are in the distance from bar to bar of a grating which he can engrave for himself on a piece of glass. How easily this is done, supposing the grating once made, was illustrated by a rapid experiment performed in the course of the lecture, without other apparatus than a little piece of glass with 250 fine parallel lines engraved on it by a diamond, and two candles and a measuring tape of unknown divisions of

[1] Abstract of lecture on "Electrical Units of Measurement," by Sir William Thomson, F.R.SS.L. and E., M.Inst.C.E., delivered on Thursday evening, May 3, 1883, at the Institution of Civil Engineers.

length (only used to measure the *ratio* of the distance between the candles to the distance of the grating from either). The experiment showed the distance from centre to centre of consecutive bars of the grating to be 32 times the wave-length of yellow light. This being remembered to be $5\cdot89 \times 10^{-5}$ of a centimetre, it was concluded that the breadth of the space on which the 250 lines are engraved is $250 . 32 . 5\cdot892 . 10^{-5}$, or ·4714 of a centimetre! According to the instrument-maker it is really ·5 of a centimetre! Five minutes spent on the experiment instead of one, and sodium flames behind fine slits, instead of open candles blowing about in the air might easily have given the result within one-half per cent. instead of $4\frac{1}{2}$ per cent. Thus the cosmic traveller can easily recover his centimetre and metre measure. To recover his unit of time is less easy. One way is to go through Foucault's experimental determination of the velocity of light.

But he must be imagined as electrically-minded; and he will certainly, therefore, think of "v," the number of electrostatic units in the electro-magnetic unit of electricity; but he will, probably, see his way better to doing what he wants by making for himself a Siemens' mercury unit (which he can do easily, now that he has his centimetre), and finding (by the British Association method, or Lorenz's with Lord Rayleigh's modification, or both), the velocity which measures its resistance in absolute measure. This velocity, as is known from Lord Rayleigh and Mrs. Sidgwick, is 9413 kilometres per mean solar second, and thus he finds, in mean solar seconds, the period of the vibrator, or arbitrary-unit chronometer, which he used in his experiments.

Still, even though this method might be chosen as the readiest and most accurate, according to present knowledge, of the fundamental data for recovering the mean solar second, the method by "v" is too interesting and too instructive in respect to elimination of properties of matter from our ultimate metrical foundations to be unconsidered. One very simple way of experimentally determining "v" is derivable from an important suggestion of Clark and Bright's paper, referred to above. Take a Leyden jar, or other condenser of moderate capacity (for example, in electrostatic measure, about 1000 centimetres), which must be accurately measured. Arrange a mechanism to charge it to an accurately measured potential of moderate amount (for example, in electrostatic measure, about 10 c.g.s., which is about 3000 volts), and discharge it through a galvanometer coil at frequent regular intervals (for example, ten times per second). This will give an intermittent current of known average strength (in the example, 10^5 electrostatic c.g.s., or about 1/300,000 c.g.s. electromagnetic, or 1/30,000 of an ampere), which is to be measured in electromagnetic measure by an ordinary galvanometer. The number found by dividing the electrostatic reckoning of the current, by the experimentally found electromagnetic reckoning of the same, is "v," in centimetres per the arbitrary unit of time, which the experimenter in search of the mean solar second has used in his electrostatic and electromagnetic details. The unit of mass which he has chosen, also arbitrarily, disappears from the resulting ratio. It is to be hoped that before long "v" will be known within 1/10 per cent. At present it is only known that it does not *probably* differ 3 per cent. from $2\cdot9 \times 10^{10}$ centimetres per mean solar second. When it is known with satisfactory accuracy, an experimenter, provided with a centimetre measure, may, any where in the universe, rate his experimental chronometer to mean solar seconds by the mere electrostatic and electromagnetic operations described above, without any reference to the sun or other natural chronometer.

The remainder of the lecture was occupied with an explanation of the application of the absolute system in all branches of electric measurement, and the definition of the now well known practical units founded on it, called ohms, volts, farads, microfarads, amperes, coulombs, watts. The name mho, found by saying ohm to a phonograph and then turning the drum backwards, was suggested for a unit of conductivity, the reciprocal of resistance. The subdivision, millimho, will be exceedingly convenient for the designation of incandescent lamps.

The British Association unit has been found by Lord Rayleigh and Mrs. Sidgwick to be ·9868 of the true ohm (10^9 centimetres per second), which differs by only 1/50 per cent. from ·9870, the number derived from Joule's electrothermal measurements described in the British Association Committee's Report of 1867, with 772 Manchester foot-pounds taken as the dynamical equivalent of the thermal unit from the measurement described in his Royal Society paper of 1849, and confirmed by his fresh measurement of 20 years later, published in his last Royal Society paper on the subject.

It is satisfactory that, whether for interpreting old results, or for making resistance-coils anew, electricians may now safely use the British Association unit as ·9868, or the Siemens unit as ·9413, of the ohm defined as 10^9 centimetres per second.

U.S. NATIONAL ACADEMY OF SCIENCES[1]

THE annual meeting of this body was held in Washington during the last week, with an attendance of forty members. Scientific sessions were held on Tuesday, Wednesday, and Friday, in the large lecture-room of the National Museum, and business sessions on every day of the meeting.

Twenty-four foreign associates were elected as follows:—Astronomers: Prof. Otto von Struve, of the Imperial Observatory at Pulkowa, Russia; Prof. J. C. Adams, of Cambridge, Eng.; Prof. A. Auwers, Director of the Observatory at Berlin; and Prof. Theo. von Oppolzer, Director of the Observatory at Vienna. Mathematicians: Prof. Arthur Cayley, of the University of Cambridge, Eng.; Prof. J. J. Sylvester, of the Johns Hopkins University, Baltimore; and Prof. E. Bertrand, of Paris. Physicists: Prof. R. Clausius, of the University of Bonn; Baron H. von Helmholtz, Professor in the University of Berlin; Prof. Robert Kirchhoff, of the University of Berlin; Prof. G. G. Stokes, of the University of Cambridge, Eng.; and Sir William Thomson, Professor in the University of Glasgow. Chemists: Prof. J. B. Dumas, Secretary of the Academy of Sciences, Paris; and Professors M. Berthelot, Boussingault, Chevreul, and Würtz, all of Paris. Geologist: Freiherr von Richthofen, Professor in the University of Bonn, and President of the German Geographical Society. Botanists: Sir J. D. Hooker, Director of the Botanical Gardens at Kew, Eng.; Prof. A. de Candolle, of Geneva. Biologists: L. Pasteur, of Paris; Prof. T. H. Huxley, of London; Prof. R. von Virchow, of the University of Berlin; A. von Kölliker, Professor of Anatomy in the University of Würzburg. Prof. Struve, one of the newly elected foreign associates, who is on a visit to this country, was a regular attendant at the scientific sessions of the Academy, and read a paper.

In consequence of the death of Prof. W. B. Rogers, the President, it became necessary to elect his successor. On the first ballot, Prof. Wolcott Gibbs, of Cambridge, one of the founders of the Academy, was elected. He, however, firmly declined the honour, from a feeling, as he said, that he could not give the time necessary to the work. The Academy reluctantly acquiesced in the decision of Prof. Gibbs, and proceeded to a second ballot, when Prof. O. C. Marsh, of New Haven, the acting President, was elected by a handsome majority. The newly-elected President will hold office for six years.

The first act of the new President was to announce that he had received from Mrs. Mary A. Draper, widow of Prof. Henry Draper, the sum of six thousand dollars, accompanied by a deed of trust which fully specified the objects she had in view. He called upon Prof. Barker to explain the nature of the trust to the Academy. Prof. Barker first made some appropriate remarks, recalling Prof. Draper's interest in the Academy, and then read the deed, the substance of which is as follows:—The income of the trust is to be used "for the purpose of striking a gold medal which shall be called the 'Henry Draper Medal,' shall be of the value of two hundred dollars," and shall be awarded from time to time, but not oftener than once in two years, as a premium to any person in the United States or elsewhere who shall make an original investigation in astronomical physics, the results of which shall be deemed by the Academy of sufficient importance and benefit to science to merit such recognition. If at any time the income of the fund shall exceed the amount necessary for the striking of the medal, the surplus may be used in aid of investigations and work in astronomical physics to be made and carried on by a citizen of the United States.

The President appointed Messrs. G. F. Barker, W. Gibbs, S. Newcomb, A. W. Wright, and C. A. Young as a committee to have charge of the fund, to make rules to govern the award of the medal, and to suggest to the Academy for approval the names of those who may be considered worthy of the award.

The Treasurer announced that in accordance with the will of

[1] From *Science*, April 27.